A Work Project, presented as part of the requirements for the Award of a Masters Degree in Management from the NOVA – School of Business and Economics.

Going with the wind: the time for time-of-use tariffs

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Abstract

This work project consists on the proposal of a product/service – Variable Time of Use Tariff – to enhance the innovativeness of the portfolio of EDP Comercial. This product/service is dependent on the simultaneous use of a smart meter, a home energy manager and a set of smart domestic appliances. To sustain my proposal I resorted to data about the wind energy, the use of smart meters together with time of use tariffs and the general characteristics of tariff structures in Europe. A SWOT analysis follows the description of the product/service, with one threat and one opportunity standing as major issues. The feasibility of the implementation of the tariff I propose depends entirely the future of these two factors, thus making this work project a future looking one.

Keywords

Wind variability

Variable tariff

Home energy manager

Energy efficiency

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1. Introduction

According to Verdelho (2010), the European energy policy is based on three pillars: competition, sustainability and supply safety. My focus will be kept on issues that are related to the pillar of sustainability since I consider it to be a major topic for discussion in current times and that more initiatives should be taken towards a more environmentally friendly world.

The concerns with sustainability are directed both to the environment and to society. The points considered to be imperative regarding environmental sustainability are the endorsement of renewable generation, the development of a marketing system of greenhouse gas emissions, internalization of externalities, encouragement of efficiency in energy consumption, smart metering and smart grids, while social sustainability involves the protection of vulnerable consumers through social tariffs (Verdelho, 2010). In my work project, the most highlighted issues are the encouragement of efficiency in energy consumption, which is directly related to the use of smart meters, and the evolution of renewable generation. Concerning the latter, I will focus only on the wind energy since I think it incorporates one of the biggest challenges of the energy market as a whole: the wind variability. Taking this into consideration, the starting point of the reasoning of my work project is the unpredictability of the wind energy and its consequences on the energy markets, taking into consideration the economic framework of the Iberian Electricity Market (MIBEL). This way, I intend to focus essentially on the innovativeness inherent to Smart Meters, Time of Use tariffs and Demand Side Management tools, since all of them will have an important role in the development of energy efficient behaviors within the entire sector.

In order to sustain my proposal I will present information about the wind energy in Portugal and the results from a Smart Metering experience that took place in Ireland and compare tariff structures from the European Union. I will use data from ERSE's website, discuss the *Electricity Smart Metering Customer Behavior Trials Findings Report* issued by the Commission for Energy Regulation and approach the *Price-setting in the Electricity Markets within the EU Single Market* report requested by the European Parliament's Committee on Industry, Research and Energy.

2. Electricity market

The liberalization process of the electricity market in Portugal began in the year 2000 and its last stage will start during the year of 2012 with the extinction of the regulation. Upon the conclusion of the liberalization process regulated tariffs will no longer exist and, therefore, the prices will be set freely by the existing suppliers in the market. Meanwhile, there will be a transitory period during which the consumers who have not yet chosen an electricity supplier from the liberalized market will still get electricity from the last resort supplier with a transitory higher tariff set by ERSE, the regulatory entity of the energy services.

EDP Serviço Universal, a branch of the EDP group, is the current supplier of last resort and after the extinction of the regulation it will no longer provide its services. EDP Comercial is another branch of the EDP group which already operates within the liberalized market. Hence, my objective is to propose an innovative product/service related to wind energy that benefits EDP Comercial in a market that is expected to become more competitive.

2.1. Wind energy in Portugal

During the first decade of the 21st century, Portugal had an average of 28,3% of its total energy generation coming from renewable sources, with values floating between 18% and 39%. Considering the commitment to reach 31% in 2020 (Verdelho, 2010), we can expect a significant growth of the investment in generation of electricity from the various types of renewable energy. In this work, the relevant type of renewable energy that is considered is the wind energy. According to UNESA (Verdelho, 2010), during the year of 2020 the wind generated power in the Iberian Electricity Market (MIBEL) can vary between 0% and 100% of the daily electricity demand (see Graphic 1). This factor, the unpredictability of the wind energy, is a crucial issue that represents one of the main challenges within the energy sector. In this sense, consequences appear both from the supply perspective and the demand perspective.

A clear consequence from the supply perspective is a higher electricity price differentiation along the day (see Graphic 2) and the need of more investment in storage capacity in order to be able to deliver enough energy to meet total demand at any moment in time, thus avoiding the risk of major blackouts. As for the demand perspective, there is the need to instigate a more efficient electricity consumption behavior by implementing innovative measures capable of increasing the demand elasticity relative to price, promoting a shift towards less expensive hours. This can be achieved by several means such as the use of Time of Use tariffs, Smart Meters, Demand Side Management tools and smart domestic appliances. Graphic 3 illustrates the daily electricity consumption per domestic appliance of a typical European household, suggesting a very significant potential positive impact on electricity consumption efficiency derived from such type of initiatives.

The most intuitive solution for coping with the variability of the wind energy is the enlargement of the storage capacity, but at the same time is the most costly. Hence, my objective is to develop a solution within the demand perspective. Therefore, in the next section, I will analyze an experiment where energy efficient enabled initiatives were used to test their impact on consumers' behavior.

2.2. Smart Metering Project

The *Electricity Smart Metering Customer Behavioral Trials* took place in Ireland during the year of 2010 and had the objective of studying how electricity consumers behave in reaction to a set of smart metering enabled energy efficiency measures, providing very statistically significant data. The specific purpose was to quantify the reduction on overall and peak electricity consumption and also the shift of consumption to night usage time, where the cost of electricity is lower. The trials were conducted both for residential customers and small-to-medium enterprises, but I will focus only on the results about the residential customers.

The set of tools involved in the trials was a combination of Smart Meters, Time of Use tariffs and a group of four Demand Side Management stimuli. A Smart Meter is a new electronic version of the traditional mechanical meter (see Figure 1) which provides more detailed information, enabling a better interaction between the customers and the electricity suppliers. It enables communications from the electricity operator to the households and vice-versa, facilitating the maintenance of the distribution network and the reduction of several costs, and it measures the electricity consumption in near-real time (every 30 minutes), which helps customers adopt new forms of behavior that enhance their efficiency in electricity consumption. The Time of Use tariffs provide the customers with different electricity prices for distinct times of the day. In these trials the day was divided into three parts for weekdays: Peak time – from 17:00 to 19:00; Day time – from 8:00 to 17:00 and from 19:00 to 23:00; and Night time – from 23:00 to 8:00. In weekends and bank holidays Peak rate does not exist, being replaced by the Day rate. There were four tariffs (A, B, C and D), each of them with its own prices for each part of the day (see Table 1). There was also a weekend tariff, but I will not consider that one in my work project given the small number of participants that was allocated to it (see Table 2). As for the Demand Side Management stimuli, three of them had the purpose of informing the customers about their electricity consumption in an efficient way and another one was applied to encourage a reduction on overall electricity consumption:

- Bi-monthly energy usage statement – three of the test groups received the regular electricity bill accompanied by a more detailed report on a bi-monthly basis. Besides the standard information about the electricity consumption and the corresponding cost the statement had the specific consumption for each Time of Use rate, hints and tips to reduce consumption and shift it to less expensive hours, a comparison of the consumption with the last period and with other consumers and the average day of the week costs;
- Monthly energy usage statement – one test group received an energy usage statement on a monthly basis;
- Electricity monitor – in-home display with information about the electricity consumption and its corresponding cost on a near-real time basis (30 minutes) and a mechanism to set a daily budget and compare it with the actual daily consumption;
- Overall Load Reduction (OLR) incentive – the OLR incentive was applied to one test group and it consisted in giving a reward of €20 to those who managed to

reduce their overall electricity consumption by 10% when compared to their usage prior to the trial, being updated on their current situation along with the bi-monthly bill.

In general, the results of the experience suggest that the implementation of Time of Use tariffs together with Demand Side Management stimuli has a positive impact on energy efficient behavior. The results show a reduction of overall and peak electricity usage of 2.5% and 8.8%, respectively, and a significant shift of electricity consumption from peak to post-peak and night periods, with 82% of participants adopting some energy efficient behaviors and 74% changing significantly their electricity consumption behavior. Concerning the bills paid by the participants, the Time of Use tariffs induced behavior changes able to create savings or, at least, prevent any possible losses that could be caused by the tariffs' structures. However, as setbacks there was no indication of a tipping point, suggesting a very inelastic electricity demand relative to price, and the shift of electricity consumption to night usage would be larger if not for some safety and convenience issues. My goal is to propose a product/service that solves, or at least mitigates, the negative impact of these two last points, thus, increasing the electricity demand elasticity relative to price and providing more convenient ways of adapting the consumption of electricity according to its cost.

2.3. European Price Structures

One of the consequences of the liberalization of electricity markets is the growing idiosyncrasy of contracts offered by the various electricity suppliers, thus, resulting in bigger differentiation of tariffs. Still, there are some characteristics that are common to most of the markets within the European Union. In my case, the relevant ones concern only the residential consumers:

- The tariffs for residential customers have a standing charge (€/kW) and a consumption charge (€/kWh);
- There are possible variations on the consumption charge according to the time of the day (e.g.: day/night; peak/off-peak) and the time of the year (e.g.: summer/winter);
- There is a pricing trade-off between standing charges and consumption charges: while one gets more expensive the other one gets cheaper.

As for the distinction between regulated markets and liberalized retail markets, the suppliers from the latter ones have more inventive price structure characteristics, like fixing prices in the long-term to protect customers from price instability, allowing some flexibility regarding the bills or providing energy management services. In the future, with further evolution of the liberalized markets, it is predictable that the emerging amount of electricity suppliers and the consequent increase in competitiveness will lead to the development of even more original price structures.

3. Proposal

The development of the product/service of my work project has the objective of solving the problems referred in the prior section in respect to electricity consumption efficiency of residential customers. Those problems are the variability of the wind energy, the highly inelastic electricity demand relative to price and the inconvenience of using domestic appliances during the night time.

The main issue to be solved, and the starting point of my work project, is the unpredictability of the wind energy. This factor makes it extremely unpractical for the suppliers to offer prices according to the amount of power generated by the wind given the large time gap between the cyclicality of the contract and the wind changes. In order for the supplier to be able to practice lower electricity prices when the wind blows stronger and higher prices when the wind is low or inexistent there has to be an adaptation of the contracts that reduces, to some extent, the effect of this time gap. Hence, my proposal consists in a tariff with price volatility that encourages consumers to better coordinate their electricity consumption with the amount of power generated by the wind.

An important condition for the successful implementation of this type of tariff would be the use of a home energy manager, which works together with a smart meter. Its need comes from the inconvenience of manually adapting the use of domestic appliances according to volatile variations of prices resulting from wind changes. Most of the people do not have the opportunity to turn on a given appliance in reaction to a price decrease warning in the very short-term (e.g.: 30 minutes earlier). The home energy manager is able to solve this problem by automatically adapting the use of a set of smart domestic appliances according to price variations. This way, my proposal does not stand by itself, involving also a partnership with a company that supplies this type of technology. GE is a good possibility since it has already made available the home energy manager and is at the moment developing the smart domestic appliances. EDP Comercial would benefit from this partnership since it would be able focus only on the development and implementation of the tariff and GE would benefit from the incentive that the tariff would represent for customers to buy home energy managers and smart domestic appliances.

3.1. Product/service characteristics

My proposal for the solution of the stated problems is a set of tariffs with upper and lower limits between which the electricity price varies along the day according to the amount of power generated by the wind.

Considering the evidences of the positive impact of Time of Use tariffs combined with other Demand Side Management stimuli on energy efficiency presented in the *Electricity Smart Metering Customer Behavior Trials Findings Report* and the price structure common characteristics description in the *Price-setting in the Electricity Markets within the EU Single Market* report, I suggest the design of a Variable Time of Use tariff (see Table 3). The tariff would have the following characteristics:

- Charges – there would be a fixed price for the standing charge, in €/kW, and a variable price for the consumption charge, in €/kWh;
- Time of Use rates – the day would be divided in two or three parts, each one with a different price consumption charge (according to the cost of energy during that period);
- Upper and lower price limits – each Time of Use rate would be defined as a price interval, rather than a fixed price, that could react to wind power fluctuations;
- Pre-defined average – the contract would include for each part of the day a price average over a determined time basis the supplier would commit to maintain to ensure customers that the supplier would not set the price always at the upper limits of the intervals; it would be adequate to define the price average over a year since along such period it is easier to predict the amount of wind generated power (see Graphic 1);
- Continuous updates – the contracts would have an appropriate time span so that they could be renewed according to growth of wind generation capacity.

Regarding the amplitude of the price intervals, the price average and the hour intervals that correspond to each part of the day, I do not define any specific values, thus, leaving some degree of freedom for the supplier to adapt the contracts to their own competitive preferences.

In order to give a clear picture of the contract conditions of the tariff I propose, I will use the existing tri-hourly tariff (see Table 4) that EDP Serviço Universal provides (to customers with contracted power up to 20,7 kVA) and adapt it to a variable model. This tariff has Peak hours (Ponta), Day hours (Cheias) and Night hours (Vazio) and the defined hours that limit each part of the day vary from Summer time to Winter time (see Figure 2).

During Summer time, the price consumption charge would be as follows:

- Peak – price varies between 0,15 and 0,19 €/kWh from 10h30 to 13h00 and from 19h30 to 21h00;
- Day – price varies between 0,12 and 0,16 €/kWh from 8h00 to 10h30, from 13h00 to 19h30 and from 21h00 to 22h00;
- Night – price varies between 0,06 and 0,10 €/kWh from 22h00 to 8h00.

During Winter time, the price consumption charge would be as follows:

- Peak – price varies between 0,15 and 0,19 €/kWh from 9h00 to 10h30 and from 18h00 to 20h30;
- Day – price varies between 0,12 and 0,16 €/kWh from 8h00 to 9h00, from 10h30 to 18h00 and from 20h30 to 22h00;
- Night – price varies between 0,06 and 0,10 €/kWh from 22h00 to 8h00.

The average price consumption charge would be 0,17 €/kWh for Peak hours, 0,14 €/kWh for Day hours and 0,08 €/kWh for Night hours along the whole year and from year to year the contract would be renewed so that both the price intervals and price averages would adapt to the evolution of the wind energy capacity. Thus, the average price consumption charge is expected to decrease along the years, meaning that the contract renewal would always benefit consumers.

3.2. Home Energy Manager

GE developed a home energy manager called Nucleus (see Figure 3) enabled with Brillion technology, which allows mutual communication with the Smart Meter and also with a set of Brillion-enabled appliances. It is a hand-sized device that plugs into an electrical outlet and wirelessly collects and stores information for up to three years about the electricity consumption and costs of the household in near real-time (every 15 seconds). Just by monitoring the energy consumption and the corresponding rates a household could adopt behaviors that are more energy efficient and, thus, reduce their electricity bill. But with the Brillion-enabled appliances the problem of the short-term price fluctuations gets solved since they are able to respond automatically to time of use pricing, adapting their functions to consume more energy in periods with lower electricity price, while maintaining a favorable equilibrium between convenience and cost. These appliances are not yet available in the market, except for the Programmable Thermostat, but GE is developing them in order to have the following characteristics:

- Dishwashers – run during hours where electricity price is lower due to its Delay Start Cycle; sets to Air-Dry in hours where price is higher;
- Double-Oven Range – when electricity price is higher it defaults to the upper oven which consumes less energy, the cook top surface decreases power use by 20% and the self-clean feature is put out of action;

- Front-Load Washer & Dryer – they can be set to run when rate is lower, delaying start until price goes down;
- Refrigerator – it adapts the defrosting cycles in order to consume more during lower price periods without causing harm to the stored food;
- GeoSpring™ hybrid water heater – uses the lowest amount of energy when price is higher without interfering with the hot water needs of the household; in eHeat™ mode it only uses 550 watts (against 4500 watts in standard electric mode);
- Programmable Thermostat - different temperature levels can be set for different times of the day and week.

For a matter of convenience, it is possible to override the automatic settings of all the Brillion-enabled appliances, thus, allowing its manual control when there are other priorities standing before an energy efficient household management.

In order to monitor the electricity consumption patterns GE made available a device which displays the information that comes directly from the Smart Meter (see Figure 4). The device displays near real time information about the electricity consumption both in kWh and Euros (see Figure 5), the time of use price that is being charged at that exact moment (see Figure 6), monthly, daily and hourly historical consumption (see Figure 7), energy analysis tools for a period defined by the customer and messages and remainders regarding utility maintenance, price fluctuations or critical saving periods.

Furthermore, the GE Nucleus energy manager comes with a software program to be installed in a computer. This way one can remotely keep track of the electricity consumption of the entire household and of each of the smart appliances as the information is transmitted wirelessly. Besides the information provided in the GE's energy display device, this software also allows the management of the thermostat from the computer (see Figure 8), with up to four settings that can be programmed for each day of the week. Moreover, there is also an iPhone app that can be downloaded from iTunes with the same functionalities of the computer software program.

3.3. Targeting

Since the set of smart domestic appliances that are necessary for the rightful implementation of the tariff I propose are not yet available, it is not possible to know for sure what their prices will be. But, according to the information that was given to me in a meeting at EDP headquarters, it is expected that the cost of this type of domestic appliances will be significantly higher than the traditional domestic appliances. This means that the savings with the product/service I propose need to be sufficiently high for the investment to payoff. As, on average, households with higher income tend to consume more electricity, they would be able to benefit more from this proposal. Therefore, the product/service I propose should be targeted to high and medium-high class households.

4. SWOT analysis

In order to have an organized list of pros and cons regarding my proposal I will describe the characteristics of the product/service that I consider to be strengths and weaknesses and then I will explain the influence of the external conditions associated to it, approaching first the threats and then the opportunities for a matter of continuity of reasoning.

4.1. Strengths:

- Flexibility – the Variable Time of Use tariffs adjust themselves dynamically to the amount of wind generated power, allowing a continuously closer relationship between the electricity price and its costs;
- Innovativeness – it is vital to keep providing customers with original products/services in order to survive in an increasingly competitive market;
- Riskless for customers – the pre-defined average price eliminates any hesitation from risk-averse or suspicious customers regarding the possibility of EDP charging prices constantly close to the upper price limit;
- Forward-looking – the tariffs were developed with a focus on the future of the energy market in the first place, considering the predictions about the growth of the wind generation capacity;
- Technology-driven – the level of innovativeness of the tariffs suits perfectly the existing technology that concerns the efficient management of a household's electricity consumption and also smart meters and the set of smart domestic appliances, which will both be made available in a near future;
- Simplicity of implementation – the product/service does not require a complex or expensive process to be integrated in EDP's portfolio, hence, being easy to make it available for consumers;
- Continuous updating process – the contract longevity is adequately defined in order to allow a constant adaptation to the evolution of the wind generation capacity.

4.2. Weaknesses:

- Complex – this type of tariff has more components (average price level and upper and lower limits) than the ones that currently exist, which might be a backset in the eyes of customers in the case they are not willing to waste time in considering the different variables;

- Unusual – the fact that this product/service is innovative and original can also be harmful since some customers might not want to switch to something different than what they got used to for a long time;
- Dependent on technology – since this type of tariffs depend on a home energy manager to properly enable energy efficiency, there is a risk associated to them since technology can always have operating problems every now and then;
- Price of smart domestic appliances – customers will have to spend a considerable amount of money to adopt this product/service because the smart domestic appliances required to potentiate its usefulness have very recent technology, hence, being much more expensive than a regular domestic appliance; still the weight of this weakness is mitigated by the fact that the tariff is targeted to high class households;

4.3. Threats:

- Economic framework – currently there is no relationship between the amount of energy generated by the wind and the prices negotiated between the wind energy producers and the electricity distributors since these prices are fixed, being the amount of electricity sold the only variable. This characteristic of the energy market does not allow the implementation of the tariff I propose in the present time, thus, making it a product/service to be considered solely for an eventual future where the inverse relationship between the amount of wind and the electricity price levels is part of the reality;

- Smart meters roll-out – the solution I present in my work project is dependent on the timing of the smart meters roll-out throughout the households, which is the government's decision;
- Dependence on partnership – since my proposal, as a whole, would be a joint effort from EDP Comercial and GE, there would always be the risk associated to the possibility of disagreements between the two parts;
- Easy to be copied – competitors can adopt the same type of tariffs given their simplicity and the lack of implementation barriers;
- Increase in energy consumption – although the home energy manager potentiates the shift of the electricity load from peak hours to other times of the day given its automatic management, it might increase the overall electricity consumption since consumers will be able to pay less for it;
- Lack of trust from consumers to rely on an automatic management of domestic appliances – as technology is always subject to operational problems, consumers might not feel attracted to this solution due to safety issues;
- More complex energy statements – the constant price fluctuations will input a lot more details into the energy statement in order for it to be accurate and will oblige EDP to spend more time and resources to construct them;
- Excessive price information – consumers might feel that they are receiving too much information about electricity consumption and costs which, with time, could cause a decrease of involvement with this solution.

4.4. Opportunities:

- Memorandum of Understanding on Specific Economic Policy Conditionality – in the section of the Memorandum which refers to the Energy markets, in chapter *5.*

Goods and services markets, there are two points related to *Energy policy instruments and taxation* that could represent opportunities for the creation of a proper economic framework for the functioning of my proposal. Point 5.13 states the objective of evaluating the fiscal incentives in regards to energy efficiency and point 5.14 refers to an adjustment of the energy policy, based on the results of the evaluation, with the objective of encouraging energy efficient behaviors and reductions in gas emission. To accomplish this objective changes will have to be made in terms of incentives and price policies, which could lead to a reality where there is actually an inverse relationship between the amount of wind power and the electricity prices, therefore, providing the necessary conditions for the implementation of the product/service I propose in my work project;

- Less investment in electricity storage capacity – since the adaptation of electricity consumption happens automatically the increase in price differentiation, which results from the growth of wind generation capacity, will not make it necessary, or at least not that much, to increase storage capacity;
- Pioneer image for EDP – the introduction of this new type of tariff structure puts EDP in a privileged position as it transmits an image of an environmentally friendly and customer-driven corporation, making it stand out from the competition;
- Growth of electricity prices – it is expected that electricity prices will increase in the upcoming years due the arising competition between suppliers given the liberalization of the energy markets, which is an incentive for people to invest in the required equipment to adopt the tariffs I propose;
- Increase electricity demand elasticity relative to price – the automaticity of the home energy manager eliminates the inconvenience of using domestic appliances during

parts of the day where no one has availability to turn them on, hence, having a considerable impact on the electricity demand elasticity relative to price, which is one of the biggest issues to be solved nowadays in the energy market;

- Incentive for people to buy smart appliances – smart domestic appliances are a strong bet for the future of the planet as they allow a big increase in energy efficiency, which gives a lot of power and dimension to the implementation of this product/service.

5. Conclusion

The goal of my work project was to develop a solution that would add value to EDP Comercial's portfolio of products/services by increasing its competitiveness and customer loyalty. For this, I focused in innovativeness in regards to energy efficiency, bringing Smart Meters, Time of Use tariffs and Demand Side Management tools into the frame of my proposal. Considering the highlight that is given nowadays to renewable types of energy, I decided to use the wind energy variability and its consequences in the energy markets as the foundation of my work project, basing myself on it to develop an idea with the potential to encourage more efficient electricity consumption behaviors on residential customers.

Taking into account the data provided in the *Energia Eólica e Impactes Tarifários* presentation I perceived the existence of the opportunity to attack this problem by charging electricity consumption in an alternative way. Bearing in mind the positive results about electricity consumption behavior from the *Electricity Smart Metering Customer Behavior Trials Findings Report* regarding the use of Smart Meters along with Time of Use tariffs and other Demand Side Management tools, and also considering the tendency for innovation showed in the *Price-setting in the Electricity Markets within the EU Single Market* report, I proposed the implementation of a Variable Time of Use tariff that would have a price interval, rather than a fixed rate, so that it could adapt dynamically according to the amount of energy generated by the wind. Since, in general, there is no time or convenience for people to manually adjust the use of their domestic appliances in response to such price variations, automaticity appeared as a necessary characteristic to be put into the picture of my proposal. The solution for this is the use of a home energy manager, which was already made available in the market by GE, which has to work together with a set of smart domestic appliances. The latter are not yet at customers' disposal, but they are being developed in the present time with the intent to automatically coordinate their functioning with the price signals received from the smart meter, thus, running when rates are lower.

Two very important factors to be considered in my work project are the current economic framework of the energy market and the action that Troika is taking within Portugal given the economic crisis. The first one does not allow conditions for my proposal to be a feasible one, since there is no relationship between the amount of wind generated power and the prices practiced by the electricity suppliers, hence, representing a major barrier for idea. But the latter one might represent an opportunity to overcome this situation, as there will be a restructuring of the instruments used in the energy markets in order to provide a better ground for energy efficiency. Therefore, the proposal of my work project is a future-looking one, trying to anticipate what might come to happen within the Iberian Energy Market by focusing on innovation and cutting edge technology.

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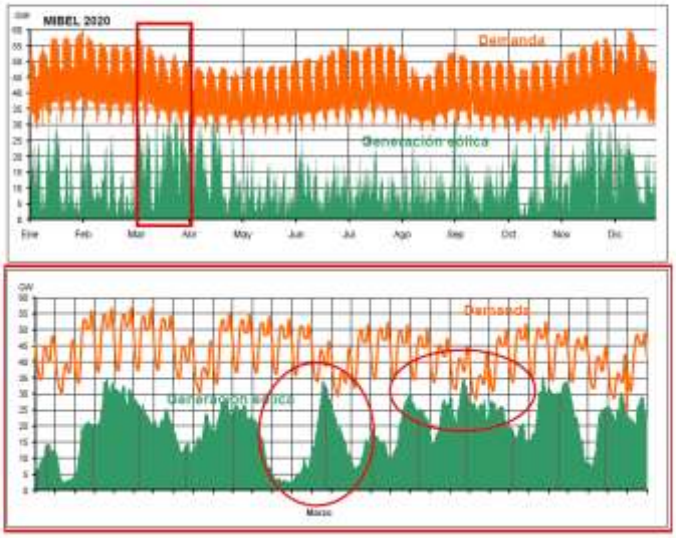
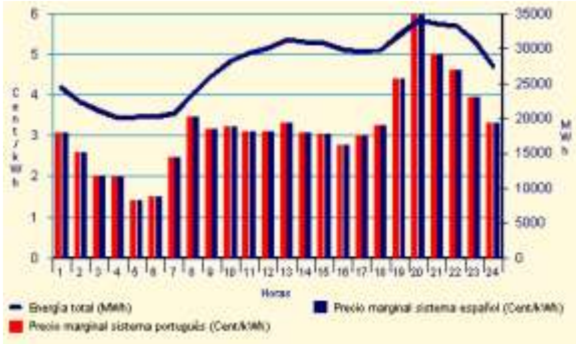
7. Appendices

Graphic 1 – Prediction of wind power generation in MIBEL for 2020



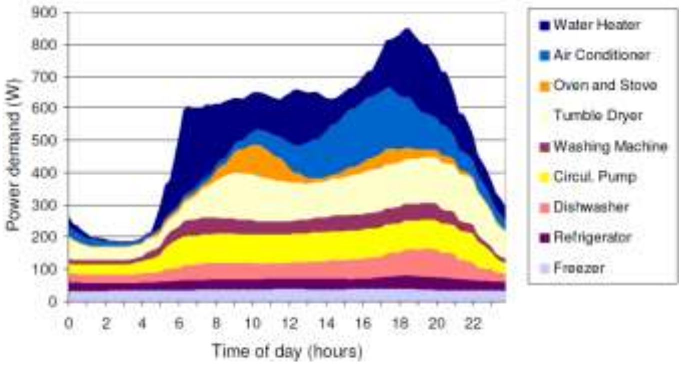
Source: Verdelho, Pedro. 2010. “Energia Eólica e Impactes Tarifários”

Graphic 2 – Price differentiation



Source: Verdelho, Pedro. 2010. “Energia Eólica e Impactes Tarifários”

Graphic 3 – Typical European household daily electricity consumption per domestic appliance



Source: Verdelho, Pedro. 2010. “Energia Eólica e Impactes Tarifários”

Figure 1 – Smart Meter

Table 1 – Time of Use Tariffs

Domestic Time of Use Tariff				
		Night 23.00 – 08.00	Day 08.00 – 17.00 19.00 – 23.00 weekdays 17.00-19.00 weekends and bank holidays	Peak 17.00 – 19.00 (Monday to Friday), excluding bank holidays
Tariff A	Cents per kWh	12.00	14.00	20.00
Tariff B	Cents per kWh	11.00	13.50	26.00
Tariff C	Cents per kWh	10.00	13.00	32.00
Tariff D	Cents per kWh	9.00	12.50	38.00

Source: Comission for Energy Regulation. 2011. “Electricity Smart Metering Customer Behaviour Trials (CBT) Findings Report”

Table 2 – Allocation of participants

Tariff	Bi-monthly bill and energy usage statement	Monthly Bill, and energy usage statement	Bi-monthly bill, energy usage statement and electricity Monitor	Bi-monthly bill, energy usage statement plus Overall Load Reduction	Total
Tariff A	342	342	342	342	1,368
Tariff B	127	129	127	128	511
Tariff C	342	342	343	343	1,370
Tariff D	127	129	126	127	509
Weekend					100
Control Group					1,170
	938	942	938	940	5,028

Source: Comission for Energy Regulation. 2011. “Electricity Smart Metering Customer Behaviour Trials (CBT) Findings Report”

Table 3 – Variable Time of Use Tariff

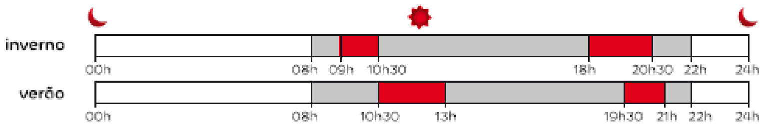
Variable Time of Use Tariff (€/kWh)			
	Peak	**Day**	**Night**
Upper limit	P+	D+	N+
Lower limit	P-	D-	N-

Table 4 – Tri-hourly tariff

PREÇO DA ENERGIA (€/kWh)	
PONTA	0,1706
CHEIAS	0,1442
VAZIO	0,0833

Source: EDP. 2012. "Tarifários 2012 potência contratada até 20,7 kVA"

Figure 2 – Tariff's daily cycle



Source: EDP. 2012. "Tarifários 2012 potência contratada até 20,7 kVA"

Figure 3 – Nucleus

Figure 4 – GE energy display

Figure 5 – Electricity consumption

Figure 7 – Historical consumption

Figure 6 – Time of Use rates

Figure 8 – Thermostat